UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: December 2020

Module Number: CE 5303 **Module Name: Hydraulic Engineering (C-18)**

[Three Hours]

[Answer **all questions**, each question carries TWELVE marks]

Q1. (a) Explain the meaning of specific energy (E) and critical depth (y_c) at an open channel section referring to the specific energy curve (E vs y). [3 marks]

(b) Prove following the usual notation Froude number, F=1 and, hence, $u^2/2g = D/2$ at critical state of flow, where $D=A/T$ is hydraulic depth. [4 marks]

(c) For a trapezoidal open channel of base width, b=6m and side slope 1V:2H, calculate critical depth of flow (y_c) if discharge, Q=15 m^3/s. [5 marks]

Q2. (a) Briefly explain the uses of the hydraulic jump in engineering applications. [4 marks]

(b) A flow of 100 m^3/s occurs in an open channel of rectangular section with width b=10 m. The upstream depth, y_1=1.0m. Determine downstream (sequent) depth, y_2 which should be maintained by the downstream control to form a hydraulic jump (Figure Q2).

The downstream depth, y_2 is given by the following relationship where, F_1 is the Froud number at the upstream section.

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2} - 1\right) \quad \text{--------Eq. 2.1}$$

[4 marks]

(c) Calculate relative energy loss, $\Delta E/E_1$ where, E_1 is specific energy at upstream section (1) and ΔE is the difference in specific energy between section 1 and 2. [4 marks]

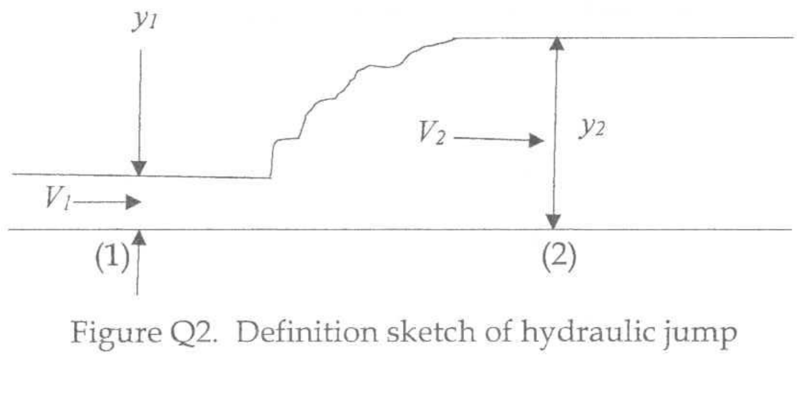

Figure Q2. Definition sketch of hydraulic jump

Q3. (a) Explain engineering applications of a sharp crested weir.

[2 marks]

(b) Derive a head-discharge relationship for a sharp-crested rectangular weir following usual notations [See Figure Q3(i) and Q3(ii)]. State any assumptions made.

[4 marks]

(c) Water flows over a sharp-crested rectangular weir 600mm wide. The measured head (relative to crest), H is 160mm at a point where cross-sectional area of the stream is 0.26m^2, i.e., at position 1 in Fig. Q3(i).

(i) Calculate discharge assuming coefficient of discharge, C_d=0.61.
(ii) What is the approach velocity, u_1 ?.
(iii) If total head, $H+u_1^2/2g$ is considered what will be the refined discharge?

[6 marks]

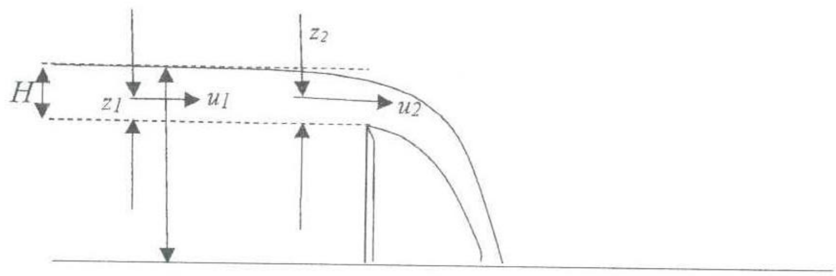

Figure Q3(i). Definition sketch of a sharp-crested weir

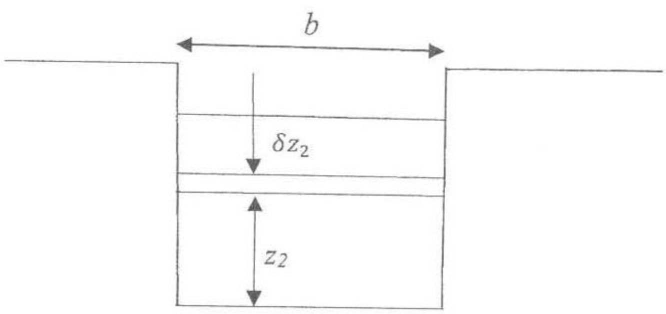

Figure Q3(ii). Elevation

Q4. (a) Briefly explain (i) critical shear stress (ii) different modes of bed load sediment transport in rivers using sketches if necessary.

[2 marks]

(b) Assuming frictional resistance force at the impending motion of a sediment particle on the channel bed is equal to μR, where, R is the force normal to the surface, $\mu = \tan\theta$ is the friction coefficient and θ is angle of repose, calculate the tractive force ratio, τ_S/τ_L. Effective area of a sand particle is a and unit tractive force on the side slope and level bed of the channel are τ_s and τ_L respectively. W_s is submerged weight of the particle.

[4 marks]

(c) (i) For a trapezoidal open channel with bottom width b=6m excavated in earth, calculate permissible unit tractive force on the slope, τ_S if the same for the level bed $\tau_L = 24\ N/m^2$. [2 mark]

(ii) If the slope of the channel mentioned in (i) is S=0.0016 and Manning roughness coefficient, n=0.025 check whether the slope will be eroded for a design discharge of 14 m^3/s under uniform flow. The maximum tractive force on the slope exerted by water flow can be assumed as, $\tau_S = 0.75(\rho g)yS$ where y is uniform depth, density of water = 1000kg/m^3, side slope, $\tan\varphi$ =0.5, angle of repose, θ = 33.5 deg, g=gravity.

[4 marks]

Figures Q4(i) and Q4 (ii) are applicable for questions Q4 (b) and Q4(c).

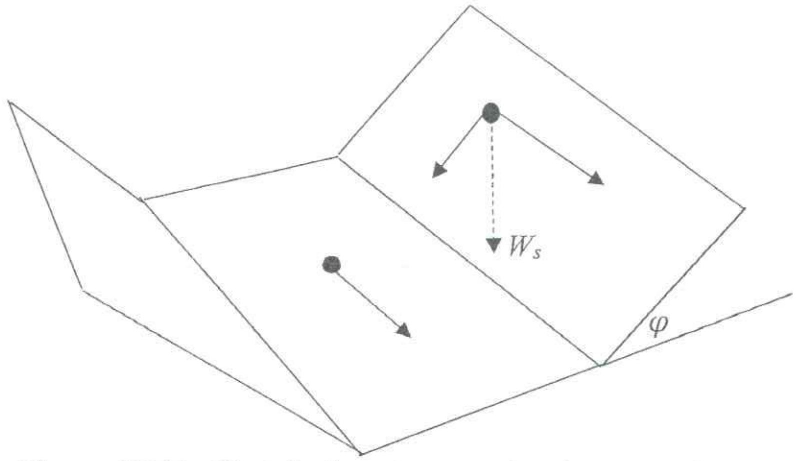

Figure Q4(i). Sketch showing tractive force on slope and level bed

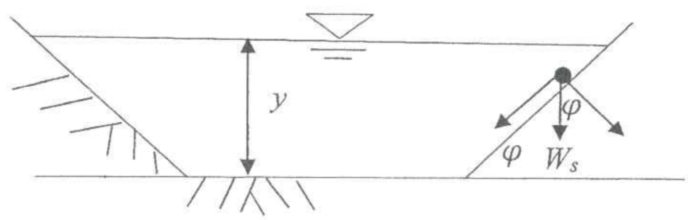

Figure Q4(ii). Cross section of the channel

Q5 (a) Compare hydraulic method of flood routing with hydrologic method and explain their strengths and weaknesses.

[4 marks]

(b) The data given in Table Q5 refer to the inflow hydrograph for a certain reach of a river which has values K = 2/3 day and X = 0.25 for Muskingum Coefficients.

Obtain the outflow hydrograph from this reach if the outflow at time, $t = 0$ is 225 m^3/s using routing equation 5.1.

$$O_{j+1} = C_0 I_{j+1} + C_1 I_j + C_2 O_j \quad \text{--------Eq. 5.1}$$

where, C_0, C_1 and C_2 are given by:

$$C_0 = \frac{\Delta t - 2KX}{m} \quad \text{----------Eq. 5.2}$$

$$C_1 = \frac{\Delta t + 2KX}{m} \quad \text{----------Eq. 5.3}$$

$$C_2 = \frac{2K(1-X) - \Delta t}{m} \quad \text{-------- Eq. 5.4}$$

$$m = 2K(1 - X) + \Delta t \quad \text{------- Eq. 5.5}$$

and

$$C_0 + C_1 + C_2 = 1 \quad \text{-------- Eq. 5.6}$$

Table Q5. Inflow hydrograph data

Time (hrs)	0	4	8	12	16	20	24
Discharge (m^3/s)	325	350	375	385	325	250	225

[8 marks]